

State Programs to Reduce Uncontrolled Ammonia Releases and Associated Injury Using the Hazardous Substances Emergency Events Surveillance System

Wendy A. Wattigney, M Stat

Nancy Rice, MPH

Debbi L. Cooper

James M. Drew, BS

Maureen F. Orr, MS

Objective: To describe how the Hazardous Substances Emergency Events Surveillance (HSEES) program identifies leading causes of uncontrolled ammonia releases and targets activities aimed at reducing the frequency of these incidents. **Methods:** Ammonia incidents reported to HSEES nationally were examined. HSEES programs in state health departments conducted and evaluated data-driven prevention outreach. **Results:** The primary targeted ammonia incidents in the three HSEES states that are presented include food manufacturing, agriculture, and events related to the production of illicit methamphetamine. Key to these prevention activities was using state-specific HSEES data to identify problems and evaluate the prevention activity, and developing partnerships with other stakeholders. **Conclusion:** HSEES data is used to identify determinants of chemical incidents and their outcomes and to help guide strategies to reduce such occurrences. Surveillance of chemical incidents elucidates the causes and consequences of these events and helps identify problems and measure the effectiveness of prevention programs. (J Occup Environ Med. 2009;51:000–000)

Ammonia is a highly poisonous, corrosive chemical compound widely used in agricultural and industrial processes. Eighty percent of ammonia produced in the world is used in agriculture as a fertilizer delivered by infusion into irrigation water or by direct injection into the soil. The food manufacturing industry uses ammonia as a chemical coolant and a refrigerant in bulk ice making and food processing. Other uses for ammonia include manufacturing dyes, drugs, synthetic fibers, plastics and explosives, and use as a component in cleaning materials. Roughly 16 million metric tons of ammonia are produced in the United States per year.¹ Large quantities of ammonia are transported across the nation for use at industrial facilities. Risk Management Plan data provided by the Environmental Protection Agency (EPA) on accidental releases estimates 68,000 US industrial facilities store ammonia on-site. In addition, large quantities of ammonia are transported to and stored by agricultural cooperatives, dealers, or retailers for use on farms. Over a million individuals who handle ammonia daily are at potential risk of serious injury in the event of accidental release. Exposure to ammonia can irritate the skin, eyes, and respiratory system; extreme exposure may cause death. The unplanned release of ammonia, especially in large quantities, poses a chemical hazard to both individuals and communities.²

From the Agency for Toxic Substance and Disease Registry (Ms Wattigney, Ms Orr), Division of Health Studies, Surveillance and Registries Branch, Atlanta, Ga; Environmental Health Division (Ms Rice), Minnesota Department of Health, St. Paul, Minn; Division of Environmental Health (Ms Cooper), Iowa Department of Public Health, Des Moines, Iowa; and Wisconsin Department of Health Services, Division of Public Health, Bureau of Environmental and Occupational Health (Mr Drew), Madison, Wis.

Address correspondence to: Wendy A. Wattigney, Agency for Toxic Substance and Disease Registry, Division of Health Studies, Surveillance and Registries Branch, MS-F57, 4770 Buford Hwy, N.E., Atlanta, GA 30341-3717; E-mail: wdw0@cdc.gov.

Copyright © 2009 by American College of Occupational and Environmental Medicine

DOI: 10.1097/JOM.0b013e318197368e

Ammonia, NH_3 , is the most commonly released hazardous chemical in work-related incidents and is the leading cause of blindness resulting from industrial accidents.³ The US Department of Labor Occupational Safety and Health Administration (OSHA) database recorded more than 60 inspections into ammonia incidents from 1995 to 2004, including more than 40 involving ammonia refrigeration.

The Agency for Toxic Substances and Disease Registry (ATSDR) established the Hazardous Substances Emergency Events Surveillance (HSEES) system in 1990 to collect information on uncontrolled releases of hazardous materials.⁴ HSEES is the only comprehensive, state-based program that captures information on the acute release of non-petroleum hazardous substances and resulting injuries and public health actions, including evacuation or shelter-in-place orders. HSEES funds state health departments through a competitive program announcement to collect information about an eligible event and enter the data into a standardized ATSDR-provided web-based system. The definition of an eligible event as prescribed in the HSEES protocol is an uncontrolled or illegal release or threatened release of one or more hazardous substances in quantity sufficient to require removal, cleanup, or neutralization according to federal, state, or local law.

Ammonia is the most frequently released chemical reported by HSEES programs. Ammonia used commercially is typically called anhydrous ammonia which emphasizes the absence of water. Although the term “ammonia” can also refer to ammonium hydroxide which is used in cleaning products and is a solution of NH_3 in water, the vast majority of ammonia releases reported to HSEES are anhydrous ammonia. These incidents often result in injury to multiple persons. Furthermore, releases of ammonia are prevalent in the agriculture industry and tend to increase during the planting and

growing season.⁵ Equipment failure and human error contribute to almost 90% of accidental industry-related ammonia releases.⁶ Anhydrous ammonia is also used to make illicit methamphetamine (meth). Thefts and dangerous releases of ammonia associated with illegal drug making emerged as a public health threat as the meth epidemic swept the nation in recent years.^{7,8} This article will review national HSEES data on ammonia releases and present several state HSEES data driven activities aimed at reducing particular ammonia releases.

Methods

HSEES state health department programs actively gather information by negotiating formal or informal agreements with state and local agencies that are routinely notified when hazardous substances emergencies occur. These agencies include but are not limited to police and fire departments, environmental agencies, and various emergency response offices. The media also serves as a resource for identifying events. For each event, industry codes are assigned to the location; information is collected about the industry, substance(s) released, victims, injuries, and evacuations; and states enter the data into a standardized ATSDR-provided web-based system. The US Census Bureau North American Industry Classification System—Revisions for 2002 was used to classify industry.⁹ Factors contributing to the events also were collected, including identification of events related to illegal drug production.

In 2002, HSEES began collecting information to identify the primary contributing factor associated with chemical incidents. The national analysis includes data from 2002 to 2005 for the 17 states that participated for varying periods due to funding cycles. For the period 2002–2005, 13 states participated for the entire period (Colorado, Iowa, Louisiana, Minnesota, Missouri, New Jersey, New York, North Carolina,

Oregon, Texas, Utah, Washington, and Wisconsin); four additional state health departments participated for various periods (Alabama: 2002–2003, Mississippi: 2002–2004, and Florida and Michigan: 2005).

In recent years, ATSDR has emphasized applying HSEES data to prevention and control. The Centers for Disease Control and Prevention’s (CDC) definition of surveillance includes the statement, “the final link of the surveillance chain is the application of these data to prevention and control.”¹⁰ HSEES states follow CDC’s *Updated Guidelines for Evaluating Surveillance Systems* which includes a *Framework for Program Evaluation in Public Health*.¹¹ Accordingly, each participating state analyzes its data and develops prevention outreach activities intended to provide industry, emergency responders, and the public with information that can help prevent chemical releases and reduce death and injury if such releases occur. Stakeholders include emergency responders such as police, firefighters, and emergency medical services; public health officials; industry organizations (eg, The International Institute of Ammonia Refrigeration); and personnel in certain industries. Outreach activities aimed at reducing uncontrolled ammonia releases and associated injuries have focused on best farming practices, refrigeration application, and illegal meth laboratories.

Iowa

The culture and economy of Iowa is deeply rooted in farming. Of the state’s 99 counties, 88 are considered rural. Approximately 650,000 to 700,000 tons of ammonia is used per year as fertilizer in agriculture. There are two ammonia producers in Iowa and over 800 retail facilities. Approximately 25,000 to 26,000 nurse tanks (mobile storage tanks) and more than 1200 permanent ammonia storage tanks are scattered across the state. Two underground ammonia pipelines covering 668 miles are located in Iowa.¹²

Since 1990, the Iowa Department of Public Health has participated in the HSEES surveillance program. Because of the high volume of ammonia used in Iowa agriculture, ammonia is the state's most commonly released hazardous substance. From 2001 to 2005, there were 532 ammonia releases (33% of all releases), and 351 (66%) were related to the agricultural industry. Of all the agricultural-related ammonia releases, 270 (77%) occurred at a fixed facility, and 81 (23%) occurred during transportation. Most accidents resulted from equipment failure or human error. More releases and injuries occur during the spring (planting season) and late fall (fall fertilizing). Employees are the most likely to be injured, and the most commonly reported injuries are chemical burns and respiratory irritation.

In response Iowa HSEES staff prepared a report on 2001–2002 acute ammonia releases in Iowa, the majority of which were agricultural-related. Iowa HSEES program staff also developed a reusable safety sticker as a strategy to reduce the risk of agricultural-related ammonia incidents (Fig. 1). For each ammonia release that occurred in 2001 and 2002, Iowa HSEES program staff

contacted the responsible party to discuss factors that contributed to the incident. The content of the safety sticker was based on these discussions. Since most of these releases occurred in Story County, Iowa, the safety sticker program was piloted in Story County. In the spring 2004, safety stickers were distributed to area farmers when they purchased ammonia at 16 retail facilities for use during planting season.

Wisconsin

Ammonia incidents comprise approximately 12% of all events reported to the Wisconsin HSEES Program. Ammonia releases in Wisconsin happen primarily in three broad areas: agriculture, the illicit manufacture of methamphetamine, and refrigerant-related releases (eg, food processing and cold storage industries). Markedly more events, victims, and evacuees occur in the ammonia refrigeration sector (ARS). During the 13 years from 1993 through 2005, among the total 667 ammonia events reported to Wisconsin HSEES, 393 (59%) of them occurred in the ARS; 121 of 268 (45%) ammonia-related victims occurred in ARS; and 6392 of 7827 (82%)

ammonia-related evacuees were associated with the ARS.

In response Wisconsin HSEES developed a program to increase awareness about the dangers of ammonia in the ARS workplace and to reduce uncontrolled ammonia releases and associated consequences. Wisconsin HSEES engaged partners including the Wisconsin Safety and Health Consultation Program; the International Institute of Ammonia Refrigeration; the University of Wisconsin-Madison, College of Engineering (Industrial Refrigeration Consortium); the Wisconsin Department of Commerce; and OSHA's Madison and Milwaukee offices to develop educational materials including a brochure. The brochure presents the characteristics and effects of ammonia, describes ammonia spills in the ARS reported to Wisconsin HSEES, and directs readers to an informational web page with pertinent links on the Wisconsin HSEES web site.¹³

The program was launched via an Ammonia Awareness Day designed to target workers in industries that use ammonia as a refrigerant. Wisconsin HSEES staff contacted 38 companies by telephone to explain the purpose of Ammonia Awareness Day. Wisconsin HSEES staff was careful to point out that the proposed educational interaction supported ongoing company ammonia management activities. The 38 companies selected to participate represented a cross-section of the ARS (ie, meat processors; specialty foods manufacturers; juice processors, cold storage/warehouse facilities; and milk, ice cream, butter and cheese manufacturers) and both smaller and larger companies.

An introductory e-mail was distributed that included attachments such as the ammonia brochure, the Wisconsin HSEES map and data on ammonia releases, a managers' overview and guide for ammonia process safety management, an EPA article addressing ammonia safety concerns in the ARS, and the link to the

ANHYDROUS AMMONIA SAFETY

BEFORE LOADING, check

- **PROTECTIVE EQUIPMENT:** Is it **READY TO USE**?
- **WHEELS, TIRES, and FRAME:** Are they in **NEED OF REPAIR**?
- **HITCH:** Is it **IN PLACE**? The **CORRECT SIZE**?
- **Did you use a KEEPER?**
- **TANKS:** Are they in **GOOD REPAIR**?
- **VALVES and SAFETY VALVES:** Do they **LEAK**?
- **HOSES:** Are they **FREE OF WEAR**?

AFTER LOADING: check

- **VALVES:** Are they **CLOSED**?
- **FLOAT GAUGE:** **TANKS NOT FILLED OVER 85%**
- **PRESSURE GAUGE:** Is tank pressure **TOO HIGH**?

REMEMBER

- Always drive at slower speeds **when pulling ammonia tanks.**
- **Maintain quick coupler after each use.**
- **Check hoses daily**
- **Check ALL valves daily**

IMPORTANT! It is YOUR responsibility to report ANY ammonia releases. If a release occurs, you must call:

- 1) Your local emergency planning committee
- 2) The National Response Center (1-800-424-8802) within 15 minutes
- 3) The Iowa Department of Natural Resources (1-515-281-8694) within six hours

IF YOU DETECT LEAKS OR OTHER PROBLEMS CONTACT YOUR DEALER IMMEDIATELY



IOWA DEPARTMENT OF PUBLIC HEALTH
Promoting and Protecting the Health of Iowans

Funding Provided by ATSDR, the Agency for Toxic Substances and Disease Registry

Fig. 1. Key guidelines to reduce the risk of accidental agricultural-related ammonia releases developed into a reusable safety sticker by Iowa Department of Public Health.

Ammonia Awareness Day web page. In addition, participants were mailed hard copies of these materials, a questionnaire to evaluate the prevention program, and a postage-paid return envelope.

Minnesota

Because ammonia is commonly used as a fertilizer and refrigerant in Minnesota, this substance is widely available in the state. Ammonia is also used as a key ingredient in the illegal production of methamphetamine, a highly addictive central nervous system stimulant sometimes produced in clandestine facilities, commonly known as “meth laboratories.” Attempts to steal ammonia for use in meth laboratories can result in large uncontrolled releases when agriculture or industrial storage tanks are damaged or tank valves are left open. Ammonia is also released when makeshift containers used by thieves fail.

The Minnesota Department of Health (MDH) joined the HSEES program in 1995 and began tracking releases of hazardous substances throughout the state. In the first 2 years of data collection, 56 releases of ammonia were recorded, but none appeared to be related to illegal methamphetamine production. In 1997, however, Minnesota HSEES recorded two ammonia releases related to tampering. These events pointed to the beginning of a surge in meth laboratories. From 1997 to 2000, there were 16 meth-related ammonia releases with 17 victims (13 emergency responders, 2 perpetrators, 2 general public) reported to HSEES. This increase, along with increasing reports and evidence of meth laboratories discovered by law enforcement agencies, suggested an emerging trend in Minnesota.

In response to this emerging public health threat, MDH staff first sent letters to sheriff's offices to alert them of the newly discovered trend, and then established the Minnesota Meth Lab Program (MLP) in 2001 to educate responders and the public on

the dangers associated with illegal meth laboratories. As the MLP endeavored to educate responders and the public on meth hazards, meth activity continued to increase, but related victims, especially first responders, declined. In 2001 and 2002, Minnesota HSEES data showed an increase in meth-related ammonia releases (18 events), with three victims (one emergency responder, two perpetrators). As meth activity became more prevalent [peaking in 2003 with 301 laboratories reported to the US Drug Enforcement Administration¹⁴ and 497 laboratories reported directly to MDH (unpublished data)], local public health agencies and other organizations began to seek more assistance from MDH. To reach several organizations at once, the MLP convened a conference in 2003 in St. Paul with support from the HSEES program. The conference reached an audience of about 160 attendees from local public health agencies, law enforce-

ment, state agencies and other organizations and featured several panel discussions focused on safe response to meth-related activity, including protection from acute and chronic chemical releases. Efforts to counter meth laboratory activity continued and legislation limiting access to pseudoephedrine and ammonia was enacted on July 1, 2005.

Results

For all participating HSEES states from 2002 to 2005, there were 2428 events involving ammonia releases (7% of all events), of which 368 events resulted in 907 victims, and 331 events resulted in slightly more than 21,000 people officially evacuated. Table 1 presents event type, type of industry, and contributing factors associated with ammonia incidents. The primary industries associated with ammonia incidents were manufacturing [non-food (24%), food (17%)], agriculture (10%), wholesale trade (9%), and non-

TABLE 1

Distribution of Selected Characteristics of Anhydrous Ammonia Incidents, HSEES 2002–2005

Variable	Number (% of Total, n = 2428)	Number With Injury (% of Total With Injury, n = 368)
Event type		
Fixed facility	2086 (85.9)	307 (83.4)
Transportation	342 (14.1)	61 (16.6)
Top 5 industries		
Manufacturing (NAICS 32)*	592 (24.4)	13 (3.5)
Manufacturing (NAICS 31)†	413 (17.0)	60 (16.3)
Private households	271 (11.2)	103 (28.0)
Agriculture	240 (9.9)	39 (10.6)
Wholesale trade	223 (9.2)	32 (9.2)
Not an industry	135 (5.6)	40 (10.9)
Contributing factor		
Equipment failure	1205 (49.6)	83 (22.6)
Human error	346 (14.3)	118 (32.1)
Illicit drug production related	566 (23.3)	139 (37.8)
Intentional or illegal act: non-illicit drug production related	200 (8.2)	16 (4.4)
Bad weather	65 (2.7)	3 (0.8)
Other	11 (0.4)	4 (1.1)
Not stated	35 (1.4)	5 (1.4)

*US Census Bureau North American Industry Classification System—Revisions for 2002 (NAICS); NAICS 32 includes wood, paper, printing, petroleum & coal, chemical, plastic & rubber, and non-metallic mineral manufacturing.

†NAICS 31 includes food, beverage, tobacco, textile, apparel, and leather & allied products manufacturing.

industry events in private households (11%). Almost one fourth of all ammonia incidents were related to illegal meth laboratories. Furthermore, illegal meth laboratories incidents accounted for 80% ammonia incidents in private households, 23% agriculture incidents and 17% incidents in the wholesale trade industry.

Victims are defined as people who suffered at least one adverse health effect or who died in association with the chemical incident. Of the events with victims, most (61%) resulted in only one victim, and 90% included less than 5 victims. Table 2 shows the distribution of victim category (employee, general public, responder, or student), injury severity, and type of injury. Injured persons, who were predominantly employees and members of the general public, were either given first aid on the

scene or treated at a hospital but not admitted. The most frequently reported injury was respiratory irritation. Of the responder injuries, 170 (80%) were related to illegal meth laboratory incidents.

Iowa

Agricultural-related ammonia releases decreased following the distribution of safety stickers (Fig. 1) to area farmers in the spring 2004. From 1999 through 2003, an average of six agricultural-related ammonia releases per year was reported to HSEES for Story County, but in 2004, only one release was reported. Distribution of the safety sticker developed by Iowa HSEES staff was expanded to an additional 15 counties (135 retail facilities) throughout 2005; 7 of these 15 counties had subsequent reductions in agricultural-related ammonia incidents.

Meeting with ammonia retail facilities, the Iowa Department of Natural Resources, the Iowa Department of Agriculture and Land Stewardship, and a cleanup contractor on ideas to prevent future releases was a key component in developing the safety sticker. Furthermore, Iowa HSEES staff learned how and where to distribute the safety stickers to maximize their effectiveness.

Wisconsin

Evaluation of the "Ammonia Awareness" program indicated the activities were effective in reducing the potential dangers of ammonia in the ARS. Of the 38 ARS companies and facilities that participated in the Ammonia Awareness Day program, 19 (50%) completed and returned the questionnaire. Responses include the following: 94% reported that the Ammonia Awareness program resulted in discussion among staff and educational initiatives; 42% identified problem areas in ongoing ammonia management activities; 74% were in favor of expanding Ammonia Awareness Day into a more formal educational or training experience; and 95% supported the

program as a useful reminder about the importance of ammonia safety practices.

The Wisconsin HSEES staff learned that establishing a partnership among agencies, academia, and industry to develop educational materials and promote the ammonia safety program proved invaluable to the program's success. Furthermore, personal contact with relevant company staff to engage participation was critical to making a positive impact.

Minnesota

To assess the impact of the new legislation limiting access to pseudoephedrine and ammonia, the MLP and Minnesota HSEES conducted surveys of all counties to determine the number of newly discovered meth laboratories^{15,16} (Fig. 2). These surveys showed a 66% reduction in newly discovered laboratories. From January to June 2005, 95 laboratories were reported by Minnesota counties in the Minnesota HSEES/MPL survey. After the law was implemented, 32 laboratories were reported for the subsequent 6-month period, July–December 2005. Other sources also reported a drop in the number of laboratories from 2005 to 2006.¹⁷ Minnesota HSEES, however, continues to capture meth-related ammonia releases; 3 releases (no victims) from January to June 2005, 2 releases (no victims) from July to December 2005, and 7 releases (2 victims) from January to June 2006.

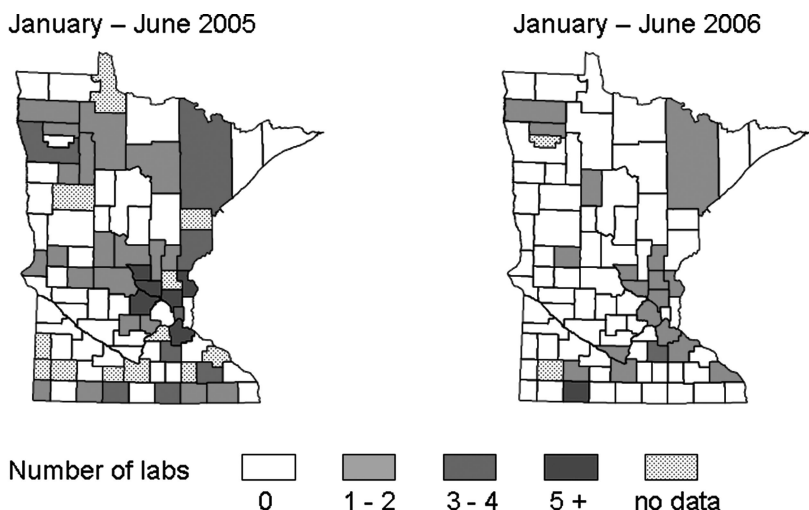
Because HSEES relies on data collected from a multitude of sources, the Minnesota HSEES program was in a unique position to observe the emerging trend in illegal meth laboratories and the hazards posed to responders and the public. The Minnesota HSEES program was able to assist in the establishment of the MLP, which then led state agencies such as the Minnesota Department of Agriculture and Minnesota Pollution Control Agency in efforts toward mitigation of this public health threat.

TABLE 2
Distribution of Selected Characteristics of People Injured, Injury Severity, and Type of Injury Associated With Anhydrous Ammonia Incidents, HSEES 2002–2005

Variable	Number (% of Total, n = 907)
Victim category	
Employee	353 (38.9)
General public	341 (37.6)
Responder*	212 (23.4)
Student	1 (<1)
Severity of injury	
Nonhospital	264 (29.1)
Hospital-released	554 (61.1)
Hospital-admitted	63 (7.0)
Died	6 (<1)
Not stated	20 (2.2)
Injury type†	
Respiratory irritation	651 (71.8)
Eye irritation	215 (23.7)
Gastrointestinal problem	118 (13.0)
Headache	163 (18.0)
Burns	82 (9.0)
Skin irritation	79 (8.7)
Dizziness/central nervous system	41 (4.5)
Trauma	27 (3.0)
Shortness of breath	23 (2.5)

*Responder includes firefighters, police, and medical personnel.

†Persons could have more than one injury type.



Data collected by the Minnesota Department of Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry

Fig. 2. Data on meth laboratories discovered before Minnesota meth precursor legislation (January–June 2005) and after the implementation of the law (January–June 2006) show a 66% decrease in newly discovered laboratories.

Discussion

Ammonia is one of the more commonly reported hazardous substances released due to accidents or illegal activity.¹⁸ Unfortunately, such releases have the potential to cause environmental contamination and human injury, including death. During the past 30 years, many organizations and agencies have contributed to the control and safe handling of hazardous substances. Ammonia refrigeration systems containing 10,000 pounds or more of ammonia are required to comply with OSHA's, 29 CFR 1910.119, Process Safety Management and the EPA Risk Management Program.^{19,20} In the private sector, engineering associations have established stringent guidelines for developing and installing systems that handle ammonia and other hazardous substances. Private industry, professional associations, and federal regulatory agencies also have developed ammonia safety management training and fact sheets to promote safety in the workplace and safety for our communities.^{21–24} The EPA's Accident Prevention and Response Manual for Anhydrous Ammonia Refrigeration System Operators is an invaluable resource for industry operators.²⁵ A Chemical Safety Alert to help deter theft of ammonia and to

prevent accidental releases was issued by EPA in March 2000.²⁶ Recommendations to farmers and industrial personnel include storing tanks in well-lit areas, using valve locks or fencing, keeping a close watch on inventory, and using a marking agent in the stored substance to help detect leaks.^{7,21,26}

Despite these efforts, the uncontrolled release of ammonia continues to pose a significant public health threat. Surveillance data retained by ATSDR and participating state health departments hold a wealth of information on acute hazardous substances releases that occur in industrial, recreational, school, and residential settings. HSEES data thereby help identify actions that can be taken to target prevention programs to reduce specific chemical hazards. Using state-specific HSEES data, each state develops activities intended to provide industry, responders, and the general public with information that can help prevent acute chemical releases or reduce harm if a release does occur. Selected ammonia-related prevention programs in three HSEES states were presented in this report. Iowa HSEES targeted ammonia users in the agricultural industry. The Wisconsin HSEES developed an ongoing

educational program for companies that use ammonia as a refrigerant. Minnesota developed a program to prevent releases and injuries associated with meth-related ammonia releases. These are just a few examples of outreach activities of HSEES state programs, and they demonstrate how the HSEES system not only collects data but also useful in efforts to identify and subsequently reduce public health hazards. These programs have also measured their success in different ways, but the long-term goal is to eliminate ammonia releases and their public health consequences.

Because of the high prevalence of ammonia releases, other HSEES states have targeted prevention in this area. For example, Texas HSEES provided ammonia spill data to food processing companies so they could identify which companies needed to implement better safety measures. Safety brochures and guidelines for clean-ups can be found at HSEES state websites. Links to individual HSEES state internet sites can be found at: http://www.atsdr.cdc.gov/HS/HSEES/State_Websites.html. Currently with ATSDR funds and state in-kind support, HSEES programs in state health departments can provide a core staff to conduct surveillance activities in the state and some prevention outreach. ATSDR is working toward a national network to expand the program and provide additional resources needed to conduct outcome evaluation and define best practices for prevention outreach.

Findings in this report are subject to at least three limitations. First, reporting of events to HSEES is not mandatory, and reporting sources vary among the states participating in HSEES. State health departments are funded to build capacity with appropriate notification agencies or resources within their state that collect reports of hazardous substance incidents. Second, the definition of an eligible incident varies among HSEES states because minimum reporting requirements vary according

to state and local laws. Therefore, the completeness of reporting and the definition of eligible events vary among states according to their reporting resources, state and local laws, and capacity to follow up on events. Third, the full impact of HSEES prevention activities is difficult to measure because these activities are augmented by other factors. For example, in Minnesota strong support for legislation to reduce meth activity came from a large number of groups, exemplifying the power of combining resources to achieve a goal. The Iowa ammonia safety sticker has been made available to other states, making its full impact likely larger than reported here. In Wisconsin materials used in the Ammonia Awareness Day were augmented by company training activities to help reduce liability. Furthermore, we live in a dynamic society where economic influences and advances in engineering technology are constantly changing and can decrease the likelihood of chemical accidents.

Adequately addressing the need to protect the public from chemical hazards requires a collaborative effort among federal, state, and local agencies and relevant stakeholders. State HSEES programs, such as the ammonia-related prevention activities presented in this report, successfully established partnerships that lay the groundwork for effective hazard reduction and prevention. Effective HSEES-driven prevention programs are shared with other public health entities to increase the effectiveness of chemical incident surveillance. These programs were able to use different strategies (safety reminder magnets, Awareness Days) and even legislation to produce positive effects. Pertinent recommendations to help deter specific releases and reduce the risk for injury are presented in detail in earlier HSEES reports.^{5,7,8,27–29} Publications are available on the HSEES internet site: <http://www.atsdr.cdc.gov/HS/HSEES/Publications.html>.

Conclusion

An alarming number of chemical accidents in the United States involve ammonia. Under the responsibilities of data collection, hazard identification, and prevention outreach, the HSEES system identified agriculture, refrigeration, and illegal meth laboratories as activities producing the most ammonia releases. Prevention activities were then targeted in these areas to reduce related releases and injuries. This report has highlighted how prevention activities in three HSEES states were then targeted in the respective areas with the purpose of reducing future ammonia releases and associated injuries.

The HSEES system also works to maximize its effectiveness by establishing partnerships for prevention outreach whenever possible. Through these efforts, HSEES works toward the goal of improved public health and safety. Educational programs and widespread dissemination of safety recommendations are required to protect people and communities from avoidable chemical dangers. Continued follow-up to measure success is needed. It is imperative that these lessons learned be incorporated into best practices for ammonia releases and casualty prevention in all states.

ATSDR is trying to reach out and broaden the chemical incident surveillance program to involve more stakeholders and coverage areas. The CDC Coordinating Office for Terrorism Planning and Response partially funds the HSEES program. The HSEES system data and prevention outreach are critical for identifying, preventing, and mitigating threats against our chemical infrastructure. In recent years HSEES has been a part of Public Health Preparedness Summits, allowing HSEES staff to establish relationships with stakeholder including but not limited to the US Department of Homeland Security, US EPA, US Department of transportation, and the Mary Kay O'Connor Process Safety Center. This is an ongoing process that will

need the support of other governmental, non-governmental organizations and the public to make it a success.

Acknowledgments

Hazardous Substances Emergency Events Surveillance represents the collaborative effort of many people whose cooperation is gratefully acknowledged. The authors thank our partners in the state health departments who worked so diligently to provide the data and perform the program activities reported in this publication.

These findings and conclusions are those of the author(s) and do not necessarily represent the views of the Agency for Toxic Substances and Disease Registry.

References

1. US Geological Survey. Available at: <http://minerals.usgs.gov/minerals/pubs/commodity/nitrogen/nitromcs05.pdf>. Accessed January 28, 2008.
2. Agency for Toxic Substances and Disease Registries. *Toxicological Profile for Ammonia: Health Effects*. 2004. Available at: <http://www.atsdr.cdc.gov/toxprofiles/tp126-c3.pdf>. Accessed January 28, 2008.
3. Chemicalspill.org. Available at: <http://www.chemicalspill.org/EPCRA-facilities/spill.html>. Accessed January 5, 2009.
4. Agency for Toxic Substances and Disease Registry. *Hazardous Substances Emergency Events Surveillance (HSEES): Fact Sheet*. 2007. Available at: <http://www.atsdr.cdc.gov/HS/HSEES/index.html>. Accessed January 28, 2008.
5. Berkowitz Z, Orr MF, Kaye WE, Haugh GS. Hazardous substances emergency events in the agriculture industry and related services in four mid-western states. *J Occup Environ Med*. 2002;44:714–723.
6. Weisskopf MG, Drew JM, Hanrahan LP, Anderson HA, Haugh GS. Hazardous ammonia releases: public health consequences and risk factors for evacuation and injury, United States, 1993–1998. *J Occup Environ Med*. 2003;45:197–204.
7. Centers for Disease Control and Prevention. Anhydrous ammonia thefts and releases associated with illicit methamphetamine production—selected states, January 2000–June 2004. *MMWR Morb Mortal Wkly Rep*. 2005;54:359–361.
8. Centers for Disease Control and Prevention. Acute public health consequences from illicit methamphetamine laboratories—selected states, January 2000–June

2004. *MMWR Morb Mortal Wkly Rep.* 2005;54:356–359.
9. US Census Bureau. *North American Industry Classification System—Revisions for 2002*. Available at: <http://www.census.gov/epcd/naics02/index.html>. Accessed February 25, 2008.
10. Centers for Disease Control. *Comprehensive Plan for Epidemiologic Surveillance. Centers for Disease Control*. Atlanta, GA: US Department of Health and Human Services (CDC); 1986.
11. Centers for Disease Control and Prevention (CDC). Updated guidelines for evaluating public health surveillance systems: recommendations from the guidelines working group. *MMWR Morb Mortal Wkly Rep.* 2001;50:1–36. Available at: <http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5013a1.htm>. Accessed June 26, 2006.
12. Iowa Department of Agriculture and Land Stewardship. Available at: <http://www.agriculture.state.ia.us>. Accessed January 28, 2008.
13. Wisconsin Division of Public Health. *Ammonia Awareness Day*. Available at: <http://dhfs.wisconsin.gov/eh/hsees/AmmoniaDay.htm>. Accessed January 28, 2008.
14. US Drug Enforcement Administration. Minnesota 2007. Available at: <http://www.dea.gov/pubs/states/minnesota.html>. Accessed January 28, 2008.
15. Minnesota Department of Health. *Meth Labs Discovered in Minnesota in 2005*. 2006. Available at: <http://www.health.state.mn.us/divs/eh/meth/ordinance/mnmethlabs2005.pdf>. Accessed January 28, 2008.
16. Minnesota Department of Health. *Meth Labs Discovered in Minnesota in 2005 and January to June, 2006*. 2006. Available at: <http://www.health.state.mn.us/divs/eh/meth/ordinance/mnmethlabs2006.pdf>. Accessed January 28, 2008.
17. Report: Meth abuse declines; Officials credit public awareness, but law-enforcement agents say they haven't seen a drop in meth supplies in Minnesota. *Minneapolis Star Tribune*. June 19, 2007.
18. Kaye WE, Orr MF, Wattigney WA. Surveillance of hazardous substances emergency events: identifying areas for public health prevention. *Int J Hyg Environ Health.* 2005;208:37–44.
19. International Institute of Ammonia Refrigeration. *Chemical Security Screening Threshold Quantity for Ammonia will be 10,000 lbs.* Available at: <http://www.iiar.org>. Accessed January 28, 2008.
20. US Department of Labor Occupational Safety and Health Administration. *Process Safety Management of Highly Hazardous Chemicals—1910.119. (29 CFR 1910.119, Process Safety Management)*. Available at http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9760. Accessed January 28, 2008.
21. The Fertilizer Institute. *You, too, Can Work for a Drug Free America: Keep Anhydrous Ammonia Safe and Secure!* Available at: <http://www.tfi.org/publications/methflyer.pdf>. Accessed January 28, 2008.
22. US Environmental Protection Agency. EPA Newsroom. *EPA and the Fertilizer Institute Develop Guidance for Retail Anhydrous Ammonia Fertilizer Facilities*. Available at: <http://www.epa.gov/newsroom/index.htm>. Accessed January 28, 2008.
23. US Department of Labor Occupational Safety and Health Administration. *Safety and Health Information Bulletin. Preventing the Uncontrolled Release of Anhydrous Ammonia at Loading Stations*. Available at: <http://www.osha.gov/dts/shib/index.html>. Accessed January 28, 2008.
24. US Department of Labor Occupational Health and Safety Administration. *Safety and Health Topics. Ammonia Refrigeration*. Available at: <http://www.osha.gov/SLTC/ammoniarefrigeration/index.html>. Accessed January 28, 2008.
25. US Environmental Protection Agency Region 7. March 2006. *Accident Prevention and Response Manual for Anhydrous Ammonia Refrigeration System Operators*. Available at: http://www.epa.gov/region07/toxics/accident_prevention_ammonia_refrigeration.pdf. Accessed January 28, 2008.
26. US Environmental Protection Agency. *Anhydrous Ammonia Theft Chemical Safety Alert*. Washington, DC: US Environmental Protection Agency; 2000. Available at <http://www.epa.gov/emergencies/docs/chem/csalert.pdf>. Accessed January 5, 2009.
27. Horton DK, Berkowitz Z, Kaye WE. The acute consequences to children exposed to hazardous substances used in illicit methamphetamine production, 1996 to 2001. *J Child Health.* 2003;1:99–108.
28. Horton DK, Berkowitz Z, Kaye WE. Surveillance of hazardous materials events in 17 states, 1993–2001: a report from the Hazardous Substances Emergency Events Surveillance (HSEES) system. *Am J Ind Med.* 2004;45:539–548.
29. Horton DK, Berkowitz Z, Kaye WE. Morbidity and mortality from hazardous materials events in the personal services industry, 1993–2001: a follow-up report from the Hazardous Substances Emergency Events Surveillance (HSEES) system. *Am J Ind Med.* 2005;47:419–427.